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A methodology to combine safety analyses and life cycle assessment for new products

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Publication date:
2004

Document Version
Publisher's PDF, also known as Version of record

Citation (APA):
Markert, F. (2004). *A methodology to combine safety analyses and life cycle assessment for new products*. Abstract from SRA Europe Annual Meeting 2004, Paris (FR), 15-17 Nov.

ABSTRACT REFERENCE NUMBER: 113

Title:	**A METHODOLOGY TO COMBINE SAFETY ANALYSES AND LIFE CYCLE ASSESSMENT FOR NEW PRODUCTS**
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Introduction & Context

A methodology is described that combine a framework for hazard identification applying functional modelling and environmental assessment applying life cycle assessment. This framework is applicable from the early stages in a products design, but can be continuously extended throughout the entire life cycle of the new product. The methodology is exemplified by the development of a new safety valve being developed in the AIRPIPE project by a European consortium (GRD1-2001-40774). Especially for components that will be used in safety critical areas, it is important to have an early assessment of the reliability and safety aspects. At this stage, it is commonly agreed that changes in a concept will be more easily implemented at lesser costs, and one should therefore also include the topics concerning sustainable production dealing with the environmental aspects and occupational health.

Method

The main principle for any life cycle (LCA) and safety assessment (SA) is the systematic collection of data relevant for conducting the analysis and assessment of environmental impacts and safety of technological processes. LCA and SA are therefore a good basis for the decision support process to find the best technological solution for a certain application within a socio-technological system.

For the present framework two established methods for SA and LCA are used: the variant of functional modelling for hazard identification described by *Rasmussen and Whetton*[7] and the EDIP method[8], respectively.

Briefly, the basic approach for the functional modelling is to sub-divide a technical system into functional subsystems. For each function called “Item” , the “Input” into and the “Output” from the function is analysed and listed. Also listed are the “Methods” to sustain the function and the “Constraints” that have to be regarded.

The basic approach conducting a LCA is to model the lifetime of a product typically dealing with occupational safety, energy demands, material flows, pollution and costs using a supply

[7] Rasmussen, Whetton; *(1997)”Hazard Identification Based on Plant Functional Modelling” Reliability Engineering & System Safety, 55, 77-84*
[8] EDIP = Environmental Design of Industrial Products in *Wenzel, Hauschild, Alting (1997) “Environmental Assessment of Products” Vol. 1, Kluwer academic publishers*

chain model, starting from the extraction of raw materials, over the manufacturing processes, and ending with the waste treatment of the product regarded. This approach is close to the functional modelling method, as each step in the supply chain can also be regarded as a "function".

By that it is possible to develop a combined model with the potential of increasing the level of detail by introducing a more specified subsystem, depending on the accessibility of data.

Results

In figure 1 the overall and coarse example of a pipeline model is indicating the input to and output from the system. Also methods and constraints that apply to the pipeline model are shown. In figure 2 the method "Emergency stop of gas flow" is further analysed and the different possible solutions are indicated (solution space). By that both the analysis for hazard and the methods used in LCA can be applied at later stages of the assessment.

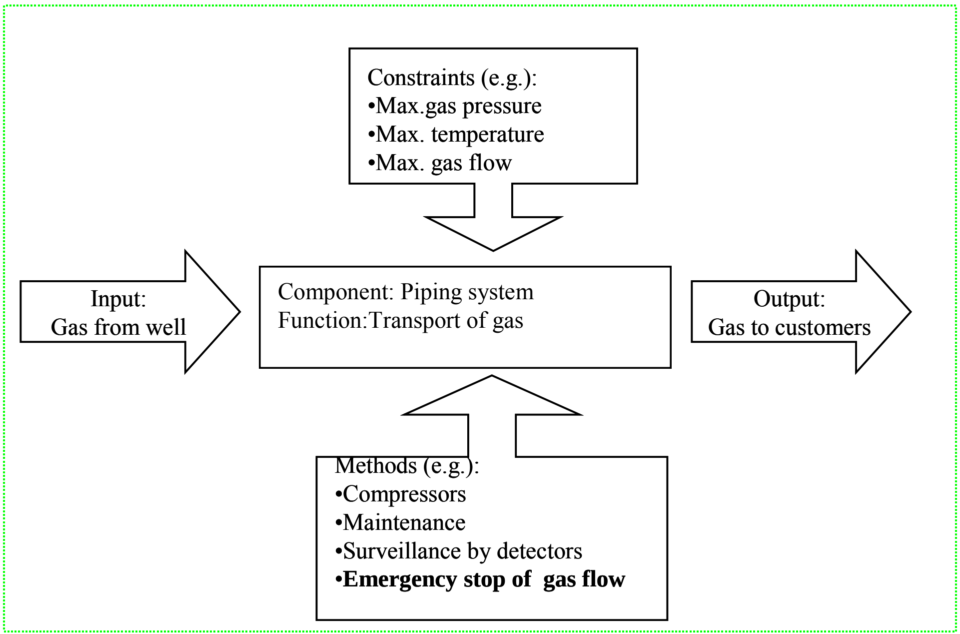

Figure 6 Example for a functional representation of an overall pipeline system. The bolded method is modelled further in the next figure.

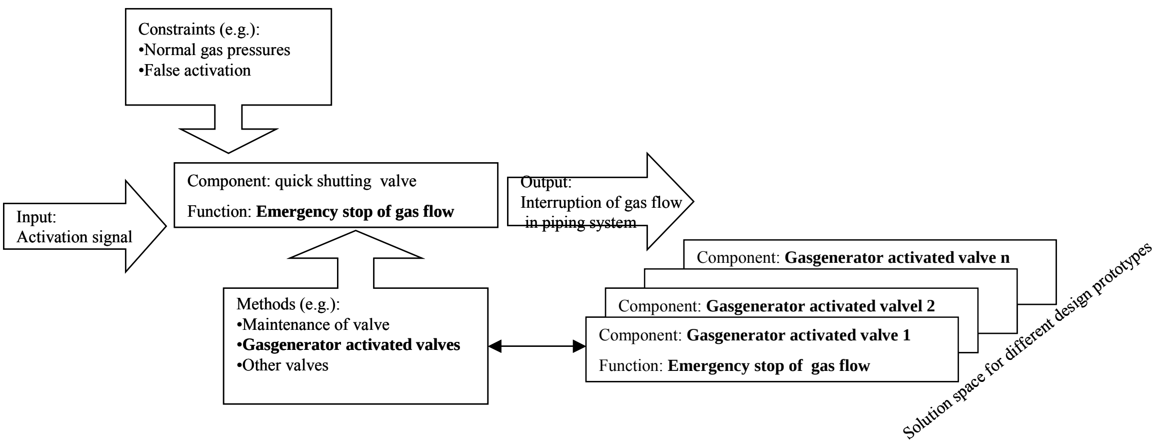

Figure 7 Example for the functional breakdown of the method "Emergency stop of gas flow". For the sub method "gas generator activated valves" a range of different solutions are indicated that make up the solution space that can fulfil the function (or service) to stop the gas flow.

Table 1 For each function/component the possible hazards are identified using a key word list and an inventory is established. The inventory is the basic step for a LCA and provides first knowledge on potential occupational and environmental hazards.

FUNCTION			HAZARD IDENTIFICATION (SA part)					INVENTORY (LCA part)		
Ref	T	Component	k	key word	Main deviation	Consequens	Mitigation	Material		
								Name	*Unit*	*Quantity*
Valve 1		Combustion chamber		Pressure	above specification	explosion	higher specification	steel	kg	2,3
Valve 1		Pyrrotechnics		Vibrations	pulverized granulate	faster combustion	avoid vibrations	GZT $Cu(NO_3)_2*Cu(OH)_2$ Zinkstearat	kg	0,2 0,7 0.02
(…)										

The analysis of the model can be listed as shown in table 1 and being analysed depending on the overall objectives. The table can be extended for other types of data depending on the objectives and scope of the analysis.

Discussions

Above it is shown how to combine a LCA and SA. In the early phases of a product development only insufficient data are available and therefore also the LCA/SA will be coarse, but new details and new knowledge on the system easily can be included into the model. By that it is possible to collect continuously and store relevant data throughout the whole life time of a product.

Conclusion & Perspectives

It is shown how to combine a life cycle assessment to analyse mostly environmental and occupational health problems including cost factors with a safety assessment regarding mostly the potential hazards and reliability of the product being used in a socio-technologic system. Combining these two approaches ensures that decisions are made on a more complete basis using one model database.